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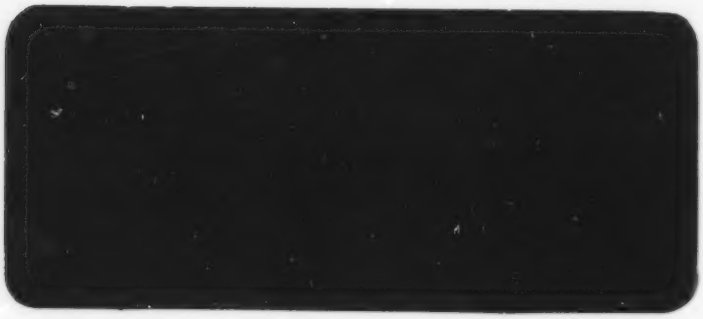

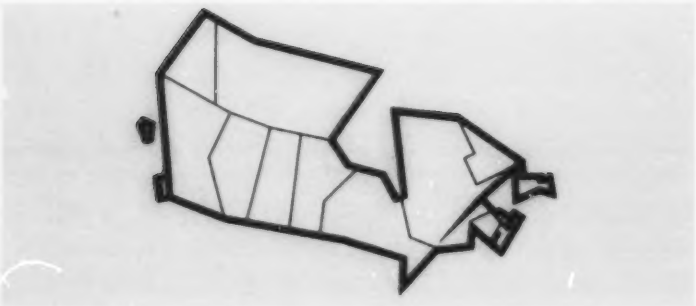

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Stress indices for spring wheat on the Canadian prairies

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Introduction

Successful production of spring wheat on the Canadian prairies is highly dependent on the kinds and degree of environmental stresses and on the management methods used by farmers to alleviate these stresses. The amount of moisture stress experienced by the crop during certain sensitive stages of growth is of prime importance. Wheat is known to be most sensitive to moisture stress during the period from jointing to soft dough; lack of moisture during this stage is most likely to result in a yield reduction.

Studies have shown that yield decreases resulting from moisture stress are closely related to the ratio of actual to potential evapotranspiration (AET/PET). (AET is the actual amount of evaporation and transpiration that occurs, while PET is the estimated amount of evaporation and transpiration that would occur if the crop was continually well supplied with moisture). A stress index, defined as (1 - AET/PET), was therefore computed on a daily basis and accumulated for the period of jointing to soft dough. This period typically spans from early June to early August in the southern prairies and about a week later in northern areas. During periods of high stress, AET will be restricted and the daily index will be close to 1, while under conditions of low stress AET will be close to PET and the daily index will be close to zero. Stress indices accumulated over the period of jointing to soft dough are mostly large positive values (e.g. over 30). Larger values indicate greater moisture stress. However, negative values can accumulate in regions with high moisture supply because AET can sometimes exceed PET when the soil is continually moist (at or near field capacity). In these cases, the daily index will be less than zero.

Information on the stress index can be helpful when planning crop rotations, evaluating the need for soil moisture conservation, and making land management decisions involving flexible cropping or other such options. Regions with large moisture stress will benefit from management techniques which conserve moisture in the soil. The purpose of this bulletin is to present information on the variability of the stress index over space and time as it occurs over the range of soil and climatic conditions experienced in the prairie region.

Stress Index Values

Stress indices for spring wheat accumulated between jointing and soft dough are presented in Figure 1 for the wheat year in a wheat/fallow rotation, and in Figure 2 for continuous wheat for the various Agroecological Resource Areas (ARAs) of the prairie region. ARAs are natural landscape areas that are more or less uniform in terms of climate, landforms, soils and crop production potential (Pettapiece, 1989, Eilers and Mills, 1990; G. Padbury, personal communication). The indices shown in Figure 1 and 2 are based on soils with 150 mm available water-holding capacity (AWC) (e.g. loams) and the 50% probability level. Stress index values can be determined for soils with other AWC's or for other probability values using the conversions shown in Table 1.

The concept of probability (risk) is used since stress indices are related to moisture supply from precipitation and these fluctuate widely from year to year. At the 50% probability level, the stress index will be equal to or less than the given value in half (50%) of the years (this is approximately equal to the long term average); at 90% probability the value given is not exceeded 9 years out of 10 (or, conversely, it is exceeded in only one year in 10). Management decisions based on the 90% probability level will be "safe" 9 years out of 10. Decisions based on 50% probability will underestimate the amount of stress in half of the years.

Stress indices computed from daily climatic records for a 30-year period (1956-1985) are presented in this bulletin. Although it is possible that some climatic changes could occur in the future as a result of the 'greenhouse' effect or other factors, such changes are expected to be very gradual and therefore the records of the past 30 years should provide a fairly reliable estimate of what may be expected in the next decade or more.

Accumulated stress indices at 50% probability for the wheat/fallow rotation (Fig. 1) range from less than 7 in northern and eastern areas of Saskatchewan and Manitoba to 24 in most of the driest portion of Saskatchewan and Alberta, particularly in the Brown Chernozemic soil zone and part of the Dark Brown Chernozemic zone. In the Peace River region of northwest Alberta, the indices are mostly in the range from over 7 to less than 18. Indices are somewhat higher (greater stress) for continuous wheat (Fig. 2), and may exceed 25 in the Brown Chernozemic soil zone at the 50% probability level. A map of the major soil groups in the prairie region is shown in Figure 3.

Accumulated stress indices can be estimated for soils with AWCs other than 150 mm and probability levels other than 50% using Table 1. Only the upper limit of each class in Figures 1 and 2 are shown in this table. Each value represents a range in class limits as is illustrated in the following example.

Extract from Table 1 - Stress indices for spring wheat (only highlighted values appear in table 1):

Stress index for 150 mm AWC 50% probability (5 yr in 10) (from Fig. 1 or 2)	Stress index for 100 mm AWC 90% probability (not exceeded 9 yr in 10) (from Table 1)
13 - 18	28 - 31
19 - 24	32 - 34

Areas with stress indices between 13 - 18 in Figures 1 and 2 (150 mm AWC, 50% probability) will have indices ranging from 28 - 31 at 90% probability on sandy loam soils. Similarly areas with index values from 19 - 24 in 150 mm AWC soil at 50% probability will have values from 32 - 34 on sandy loam soils at 90% probability. Similar procedures can be applied to other soils and probability levels. The relationship between stress indices for 150 mm AWC soils at 50%

probability and other soils and probability levels was very similar for both continuous wheat and wheat/fallow rotations, and thus only one table of values was needed.

To fully utilize the available information on stress indices for management decisions requires more research. However, the present results provide some comparisons which may be helpful. Results in Table 1 indicate that although stress indices tend to be higher on coarser-textured soils (e.g. sandy loams), the effect of texture on the stress index tends to be small. This implies that climatic differences over space and time are of greater importance in determining the optimum management decisions than soil textural class. With the possible exception of the Peace river region, areas with similar stress index classes should require similar management techniques for moisture conservation, regardless of the AWC of the soil. Summerfallowing, as a technique for management of moisture stress in spring wheat, is most commonly used in areas with the highest stress indices, i.e. indices of greater than 25 (Fig. 2). These areas may experience the highest comparative benefit from flexible cropping and conservation tillage for soil moisture conservation (Bootsma, et al. 1992).

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Table 1. Stress indices for spring wheat from jointing to soft dough at 4 soil AWC's and several probability levels for both continuous wheat and wheat/fallow rotation.*

Stress indices for several soil classes, AWC and Probability levels																				
Stress Index for 150 mm AWC	Sandy Loam 100 mm AWC					Loam 150 mm AWC				Clay loam 200 mm AWC					Clay 250 mm AWC					
50% probability	10%	25%	50%	75%	90%	10%	25%	75%	90%	10%	25%	50%	75%	90%	10%	25%	50%	75%	90%	
0	-2	1	5	12	18	-6	-4	7	13	-6	-3	0	5	10	-7	-5	-2	3	8	
6	0	4	10	17	23	-4	0	13	19	-4	0	5	11	16	-5	-2	4	9	15	
12	2	8	15	22	27	-2	4	20	25	-1	4	10	17	22	-1	3	10	17	22	
18	5	11	19	26	31	3	10	26	31	4	9	16	23	28	4	9	16	23	29	
24	11	17	23	30	34	10	17	31	35	10	16	22	28	33	11	16	23	28	33	
30	20	24	29	33	37	21	26	34	37	19	23	28	33	36	19	23	28	32	35	

* Conversions for continuous wheat and wheat/fallow rotation are the same for a given stress index.

Figure 1. Stress index for 150 mm AWC soil, 50% probability, wheat/fallow rotation.

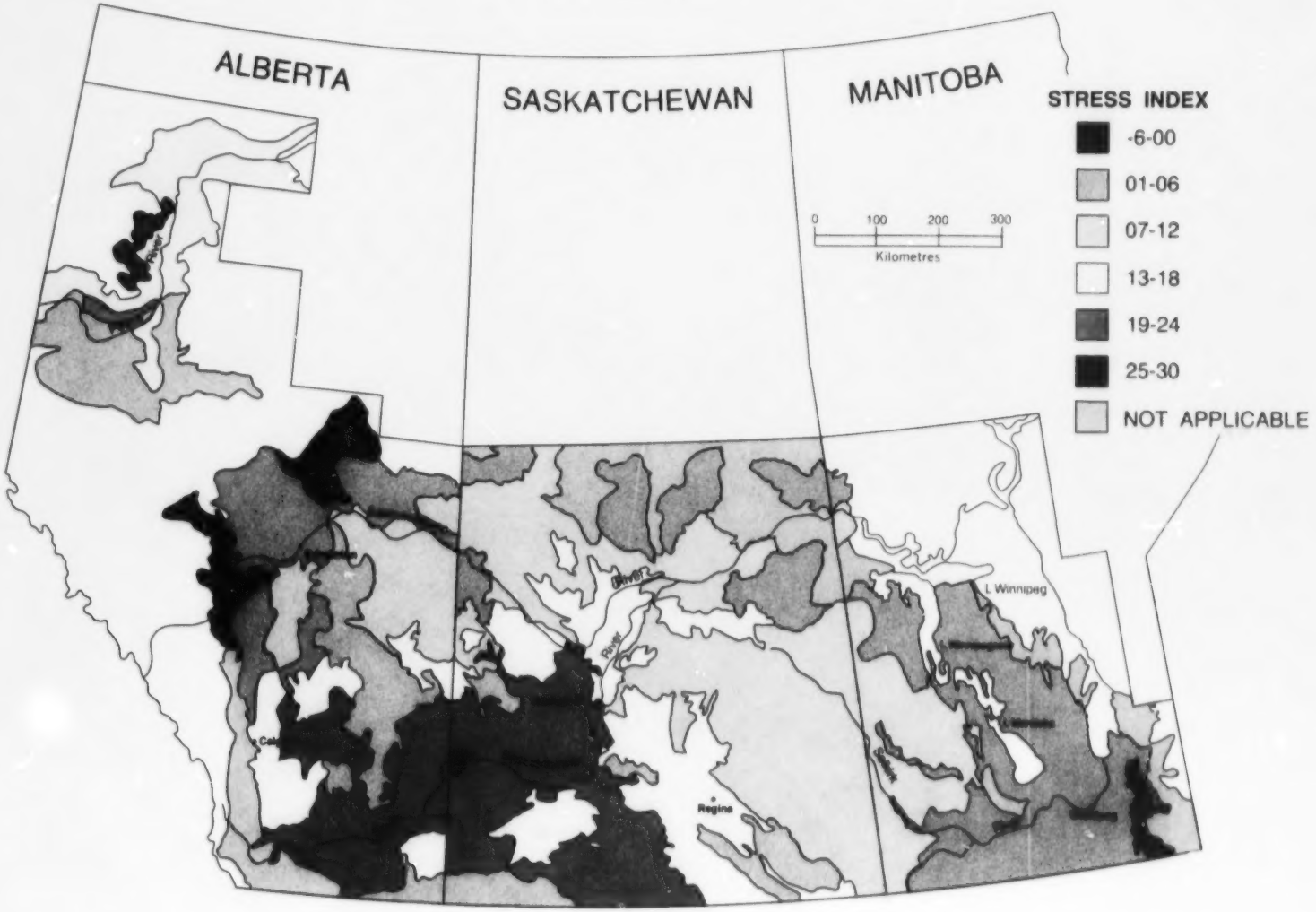

Figure 2. Stress index for 150 mm AWC soil, 50% probability, continuous wheat rotation.

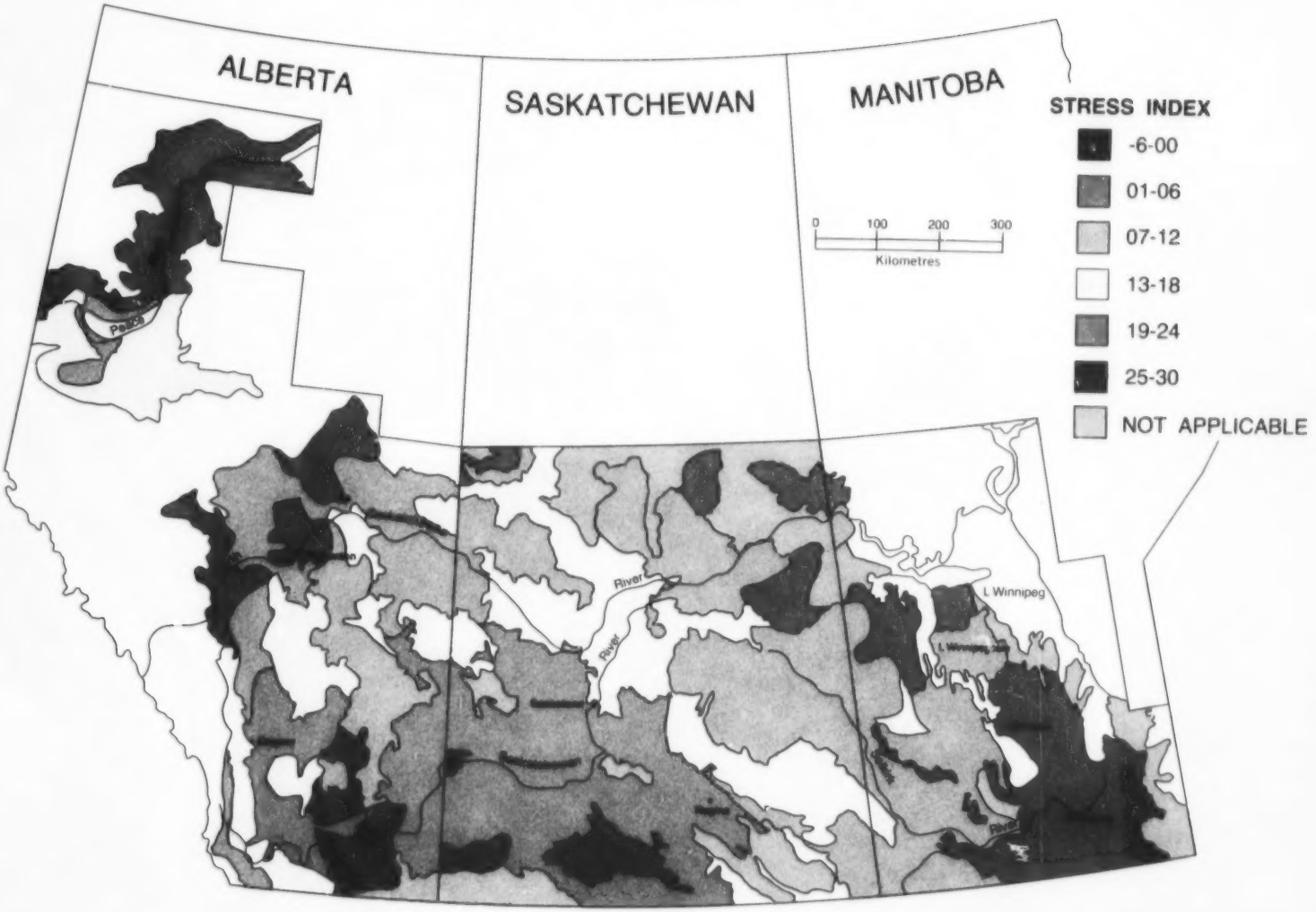

Figure 3. Location of major soil groups in the prairie region